RESEARCH ARTICLE OPEN ACCESS

Mineralogy of talcschist geological formations in the Douigny (South-West Gabon)

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ABSTRACT
Talcschist samples taken in the department of Douigny, in southwestern Gabon, known for its presence of talc, were the subject of mineralogical, morphometric and surface characterization. The goal is to identify the most interesting industrial applications. The Douigny samples collected and analyzed using X-Ray Diffraction confirm the presence of talc on total rock with typical peaks at 9.32 Å, 3.12 Å and 4.68 Å. Talc is associated with the procession of minerals such as: quartz, dolomite, calcite, and more or less traces of chlorite. Scanning Electron Microscopy on coarse fraction shows a morphology in sheets of pure talc. Diffuse Transmission and Reflection Infrared shows bands related to OH elongation, hydration and HOH deformation with respective wavelengths at 3698 cm-1 to 3620 cm-1 for OH and 1678 cm-1 to 1611 cm -1 for talc HOH. The average talc content of the prospected sites is around 70% pure talc, which predisposes the mineral materials containing talc from La Douigny to uses in painting, stationery and ceramics.

Keywords: Douigny, Mineral materials, South-West Gabon, Talc, Industrial uses

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Date of Submission: 24-12-2022 Date of Acceptance: 04-01-2023

I. Introduction

Gabon shows great variations in its geology, with rocks dating from the Archean (>2,500 Ma) to recent Cenozoic deposits [1]. In the manuscripts of [2, 3], mention is made of the major lithostratigraphic units of Gabon (Fig. 1). The first indications of the existence of a talc deposit in the Tchibanga region date from the 1940s with the prospecting work carried out by [4] which showed the presence of steatite. Research focused on talc in the Nyanga basin began with the impetus of the work carried out by [5], on the northeast flank near Ndendé, demonstrating the existence of masses in economic volume but of medium quality. In the vast Nyanga synclinorium, the talc level is located in the upper part of the Schisto-limestone succession, [5]. Nyanga talc is continuously recognized all around the synclinal structure, suggesting a sedimentary or diagenetic origin [6]. In the syntheses of [7], we chose to focus on the mineralogical characterization of the cardinal phases of talcschist deposits in superficial and accessible zones.

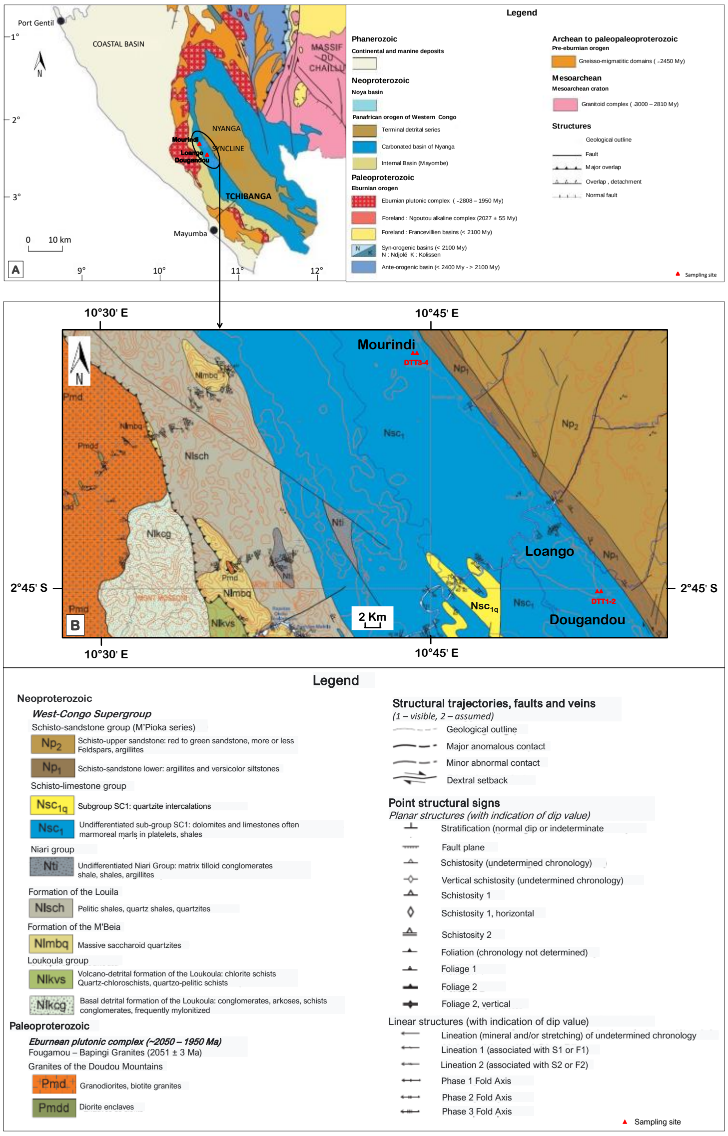

Figure 1: The major lithostratigraphic units of Gabon (A) [1] and Location of the Douigny talcschists (B)

II. Materials and Methods

The Douigny samples were taken from four sites (DTT1, DTT2, DTT3 and DTT4) on the edge of the Tchibanga-Moabi highway in a South East – North West direction. The sampling method (Number of most characteristic samples, location of sites by GPS, descriptive outcrop data), exploits the topographic and geological information available in the literature [8, 9, 10]. The sites contain fine talc materials of whitish to yellowish color. The names assigned to the samples are DTT1 and DTT2 for Loango-Dougandou and DTT3 and DTT4 for Mourindi. The rock is not very cohesive and crumbles by hand, the fractures are earthy to imperfect. The samples are dried in an oven at 60°C for 24 hours, ground to 500 micrometers, packaged in duly referenced plastic bags. The fine fraction is used for microscopic analyzes in the laboratory. Chemical analyzes of the major elements in whole rock, SiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, Na_2O, Ca_2O, K_2O, TiO_2 and P_2O_5 and traces, are carried out at the CRPG in Nancy, by emission spectrometry, using a Jobin Yvon 70-P quantometer equipped with an ICP plasma. The quantities measured are expressed in percentages of oxides for the major ones and in ppm for the traces relative to the weight of the sample at 110°C. Mineralogical determination in whole rock is based on X-ray diffraction analyzes of disoriented powders. The device used is a Bruker D8 advance diffractometer operating by reflection under the incidence of Kα1 radiation from cobalt (λ = 1.789 Å) without a physical monochromator. The determination of the species is carried out by comparison with the data of the "Powder Diffraction

File" of the International Center for Diffraction Data (ICDD). Infrared spectroscopy is carried out in diffuse reflection between 600 and 4000 cm-1 on a powder dilution of 50 mg of sample in 270 mg of KBr, using a Bruker IFS 55 spectroscope. Talcschist materials are characterized using the vibration frequencies of their functional groups [11]. Scanning electron microscopy exploits the interaction between an electron beam and the sample. We used a Hitashi FEG S 4800 set, equipped with an energy dispersion spectroscope (Si-Li Thermo-Noran set) and a backscattered electron detector. The set provides access to secondary electron images, backscattered electron images and emission fluorescence spectra (EDS). The modal proportions were determined according to the multilinear methods developed by [12, 13] whose base is not constrained to the expression:

$$T(a) = \sum_{1}^{n} Mi \times Pi(a)$$

With:
T(a) = Content (%) of element « a » in the material,
Mi = content (%) of mineral « i » in the material and
Pi(a) = proportion of element « a » in mineral « i ».

III. Results and discussions

Macroscopic observation of the mineral deposits of the talcschists of La Douigny and its surroundings shows massive stratified outcrops made up of more or less clayey fine sands, whitish to yellowish in color overall for altered levels, and sheet structures for primary tectonized and dolomitic levels. The talc material DTT3 and DTT4, is a pure primary talc between the layers of the carbonates showing a rectified mylonitic cataclastic structure and a localized crushing system. A subvertical N130°E direction of the primary talc is observed in (Fig. 2). We see lenticular particles in the straightened foliation. Towards the crushed heart centimetric lenses can reach 10 to 20 cm in thickness. Carbonate lenses alternate with primary talc lenses. Locally, primary talc largely predominates over a thickness of about 10 cm (Fig. 3). The DTT1 and DTT2 samples are taken from an outcrop of a pocket of pure talc with traces of iron oxyhydroxides, leading to brown talc under a sandstone cap in gravel with the presence of furrows, signs of alterations due to the passage of meteorite water.

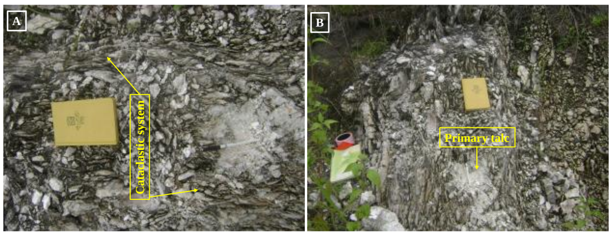

Figure 2: Primary talc with straightened structure and grinding system (A), direction N130°E subvertical of the primary talc (B) from La Douigny

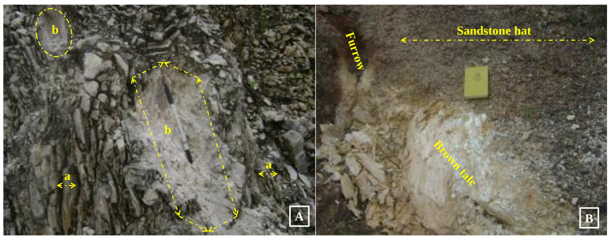

Figure 3: The level of talcschist with an upright structure (a) and the powdery dolomitic structure (b) in part (A) then the outcrop of brown talc in part (B) of the Douigny

The chemical analyzes of the majors (Table 1) show the presence of oxides of the elements in agreement with the results obtained by Clarke and Goldschmidt [14]. The values are well above the average content of chemical elements found on the surface of the earth [15]. The SiO2 oxide of the DTT1 and DTT2 materials exceeds 59%. The DTT3 and DTT4 materials have a percentage of silica lower than 59%. The MgO oxides of the DTT1, DTT3 and DTT4 materials have average values that exceed 15%, with the exception of the DTT2 material which loops at 13.66%. In the law of distribution and association of major (contents > 1%) and minor (between 1 and 0.1%) elements, magnesium and silicon are in majority proportion as shown by Clarke and Goldschmidt in [14]. The Douigny talcschist mineral materials are sandy to clayey chlorite-kaolinic talcs with an average chlorite content of 4.37% (Table 2), and an average kaolinite content of 1.14% in the DTT1 and DTT2 materials (Table 2).

The trace elements (<0.1%) show, for the materials (DTT1 and DTT2), the presence of significant levels of Cerium (50% and 15.08%), Chromium (13.32% and 19, 78%), Vanadium (14.85% and 11.39%) and Zirconium (14.4% and 7.67%) from table 1 (B) that the trace elements observed in the schisto-limestones of Douigny could come from mantle rocks, which can be supported by the presence of faults due to tectonic movements in the region. In hypothesis, we think that the Douigny talc would be of hydrothermal origin with regard to the presence in all the materials of chalcophilic to siderophilic elements without detection limit [14]. The average molar proportions of the essential minerals (Table 2) are talc materials (58.04%) for the DTT1 and DTT2 materials and 78.02% for the DTT3 and DTT4 materials; quartz (30.78%) for DTT1 and DTT2 then 11.5% of DTT3 and DTT4 materials; 8.19% chlorite for DTT1 and DTT2 materials then 0.55% for DTT3 and DTT4 materials. Incidentally, kaolinite is at an average of 1.14%, present in DTT1 and DTT2 materials, absent from DTT3 and DTT4 materials. The unidentified phases have average proportions of 1.86% for the DTT1 and DTT2 materials then 0.94% for the DTT3 and DTT4 materials. From these proportions, we say that the materials DTT1 and DTT2 are composed of secondary talc and that of DTT3 and DTT4 are of primary talc (Table 2).

Table 1: Major oxides (A) and trace elements (B) of chemical analyzes on whole rock of talcschists in the Douigny

Samples	% Major oxides (A)											
	SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	PF	Total
DTT1	63,32	1,61	0,69	0,00	27,97	< L.D.	0,10	< L.D.	0,03	< L.D.	5,86	99,59
DTT2	82,03	0,61	0,44	0,00	13,66	0,03	0,05	< L.D.	0,03	< L.D.	2,99	99,84
DTT3	19,60	0,04	< L.D.	0,00	22,69	22,05	0,04	< L.D.	< L.D.	< L.D.	34,44	98,87
DTT4	36,79	0,06	< L.D.	0,00	27,45	12,45	0,09	< L.D.	< L.D.	< L.D.	22,36	99,20

% Trace elements in ppm (B)									
% Elements	Samples				% Elements	Samples			
	DTT1	DTT2	DTT3	DTT4		DTT1	DTT2	DTT3	DTT4
As(ppm)	1,205	1,382	< L.D.	< L.D.	Nb	0,419	0,453	< L.D.	< L.D.
Ba	< L.D.	1,624	2,267	2,212	Nd	3,181	1,53	0,101	0,109
Be	< L.D.	< L.D.	< L.D.	< L.D.	Ni	< L.D.	< L.D.	< L.D.	< L.D.
Bi	< L.D.	< L.D.	< L.D.	< L.D.	Pb	6,967	4,9648	< L.D.	< L.D.
Cd	< L.D.	< L.D.	< L.D.	< L.D.	Pr	0,901	0,411	0,029	0,029
Ce	50,62	15,08	0,277	0,189	Rb	< L.D.	< L.D.	< L.D.	< L.D.
Co	1,541	0,827	0,458	0,366	Sc	1,81	< L.D.	< L.D.	< L.D.
Cr	13,32	19,78	< L.D.	< L.D.	Sb	< L.D.	< L.D.	< L.D.	< L.D.
Cs	< L.D.	< L.D.	< L.D.	< L.D.	Sm	0,593	0,276	0,017	0,02
Cu	< L.D.	< L.D.	< L.D.	< L.D.	Sn	< L.D.	< L.D.	< L.D.	< L.D.
Dy	0,596	0,261	0,012	0,032	Sr	< L.D.	< L.D.	63,97	35,32
Er	0,282	0,135	< L.D.	0,011	Ta	0,035	0,036	< L.D.	< L.D.
Eu	0,128	0,062	0,007	< L.D.	Tb	0,102	0,046	< L.D.	< L.D.
Ga	0,626	0,502	< L.D.	< L.D.	Th	2,433	1,025	< L.D.	0,035
Gd	0,829	0,358	< L.D.	0,016	Tm	0,036	0,02	0,001	0,002
Ge	< L.D.	< L.D.	< L.D.	< L.D.	U	0,363	0,39	0,097	0,057
Hf	0,381	0,193	< L.D.	< L.D.	V	14,85	11,39	4,623	5,603
Ho	0,112	0,05	0,003	0,003	W	< L.D.	0,588	< L.D.	< L.D.
In	< L.D.	< L.D.	< L.D.	< L.D.	Y	3,957	1,637	< L.D.	0,408
La	5,751	2,561	0,181	0,138	Yb	0,241	0,12	< L.D.	0,011
Lu	0,033	0,017	< L.D.	< L.D.	Zn	< L.D.	< L.D.	< L.D.	< L.D.
Mo	< L.D.	0,526	< L.D.	< L.D.	Zr	14,4	7,67	< L.D.	< L.D.

Table 2: Mass content of minerals in the materials of the Douigny talcschists

Samples	Mineral	Chemical formula	Mass content (%)	Total (%)
DTT1	Quartz	SiO_2	10,15	
	Talc	$Mg_3(OH)_2Si_4O_{10}$	78,45	**99,28**
	Kaolinite	$Al_2Si_2O_5(OH)_4$	0,73	
	Chlorite	$Mg_{(6-x-y)}Fe_yAl_x(Si_{(4-x)}Al_x)O_{10}(OH)_8$.	9,95	
	Others			**0,72**
DTT2	Quartz	SiO_2	51,41	
	Talc	$Mg_3(OH)_2Si_4O_{10}$	37,62	**97,00**
	Kaolinite	$Al_2Si_2O_5(OH)_4$	1,54	
	Chlorite.	$Mg_{(6-x-y)}Fe_yAl_x(Si_{(4-x)}Al_x)O_{10}(OH)_8$.	6,43	
	Others			**3,00**
DTT3	Quartz	SiO_2	13,01	
	Talc	$Mg_3(OH)_2Si_4O_{10}$	70,68	**98,75**
	Dolomite	$CaMg(CO3)_2$	9,48	
	Calcite	CaCO3	5,148	
	Chlorite.	$Mg_{(6-x-y)}Fe_yAl_x(Si_{(4-x)}Al_x)O_{10}(OH)_8$.	0,44	
	Others			**1,25**
DTT4	Quartz	SiO_2	9,99	
	Talc	$Mg_3(OH)_2Si_4O_{10}$	85,36	**99,38**
	Dolomite	$CaMg(CO3)_2$	2,19	
	Calcite	CaCO3	1,19	
	Chlorite.	$Mg_{(6-x-y)}Fe_yAl_x(Si_{(4-x)}Al_x)O_{10}(OH)_8$.	0,65	
	Others			**0,62**

The mineral materials of DTT1 and DTT2 are composed of talc, quartz, more or less chlorite and kaolinite as a whole. The values of the peaks of the diffractograms characterizing them are in FIG. 4 A according to the respective intensities below: Talc: 9.31 Å; 3.12Å; 4.66 Å; 1.87Å; 1.82 Å; 2.28 Å; 2.23Å; 1.98Å; Quartz: 3.34Å; 4.25Å; 1.82 Å; 2.45Å; 2.13 Å; 2.33 Å; 2.28 Å; 2.23Å; 1.98Å; Chlorite: 12.95 Å; Kaolinite: 7.16 Å; 3.58 Å; 2.33 Å. Whole-rock X-ray diffraction of materials (DTT3 and DTT4) gives the mineral phases talc, quartz, chlorite, dolomite and calcite. Their identifications are based on reticular equidistances and corresponding intensities. Whole-rock X-ray diffraction of materials (DTT3 and DTT4) gives the mineral phases talc, quartz, chlorite, dolomite and calcite. Their identifications are based on reticular equidistances and corresponding intensities. The X-ray diffractogram of mineral materials from DTT3 reveals talc, quartz, dolomite, calcite and more or less chlorite (Fig. 4 B), whose identification is based on the following sets of equidistances : Talc: 9 .39Å; 3.12Å; 4.69 Å; 1.87Å; 1.80 Å; 2.34Å; 2.06 Å; 1.85Å; Quartz: 3.34Å; 1.80 Å; Chlorite: 13.05 Å; 2.60 Å; Dolomite: 2.89 Å; 2.19 Å; 2.01 Å; 1.80 Å; 2.67Å; 2.40 Å; 2.54 Å; 3.70Å; 4.04Å; Calcite: 3.03Å; 1.85Å; 1.80 Å. On the X-ray diffractogram of the mineral materials of DTT4, the minerals are identified as follows: talc, quartz, dolomite more or less chlorite (Fig. 4 C). Talc: 9.35 Å; 3.12Å; 4.67Å; 4.56 Å; 1.87Å; 1.80 Å; 4.35Å; 2.59 Å; 2.48 Å; 2.34Å; 2.06 Å. Quartz: 3.34Å; 1.80 Å. Dolomite: 2.88 Å; 2.19 Å; 2.02Å; 1.80 Å; 4.03 Å; 3.69 Å; 2.67Å; 2.40 Å; 2.54 Å; 3.69 Å; 4.03 Å. Calcite: 1.85Å; 1.80 Å. DTT4 talcschists do not show the major calcite reflection unlike the DTT3 material where it is detected at 3.03 Å.

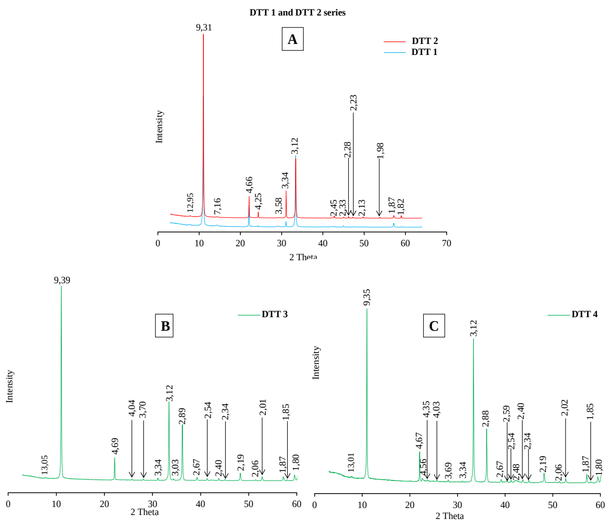

Figure 4: Douigny X-ray diffractogram on whole rock A: (DTT1; DTT2) B: (DTT3) and C: (DTT4)

DOI: 10.9790/9622-13012631

The Transmission Infrared spectra of Loango-Dougandou talcschist materials are plotted in Fig. A. Band assignments are as follows: 3698 cm^{-1}, 3676 cm^{-1}, 3650 cm-1 and 3620 cm^{-1} for OH stretches; the broad band centered on 3441 cm^{-1} corresponds to the elongation of the proton in molecular water and the leader of small resolved band corresponds to the elongation of a structural proton of the gibbsite, 1637 cm^{-1} HOH hydration and deformation band, 1426 cm^{-1}, characteristic of traces of carbonates, 1021 cm^{-1} corresponds to the elongation of SiO, 795 cm^{-1}, 783 cm^{-1} and 684 cm^{-1} bands corresponding to SiO deformations, 669 cm^{-1} is the deformation of OH, 535 cm^{-1} is the band that corresponds to the elongation of MgO. The Transmission Infrared spectra of the Mourindi talcschist materials are shown in Fig. B. Band assignments are: 3676 cm^{-1}, OH stretches; 1615 cm^{-1}, hydration and deformation of the HOHs, which could make us think of a Si-O contribution, the signal from the carbonates is around 1430 cm-1 or a little beyond. 1439 cm^{-1}, traces of the carbonates, 1022 cm^{-1}, elongation of SiO, 881 cm^{-1}, 729 cm^{-1} and 683 cm^{-1}, SiO deformations, 669 cm^{-1}, OH deformation, 534 cm^{-1}, the elongation of MgO. The infrared spectra in diffuse reflection on whole rock of the DTT1 and DTT2 materials are shown in Fig. 5 C. The assignments of the infrared bands are: 3698 cm^{-1}, 3676 cm^{-1}, 3656 cm^{-1} and 3620 cm^{-1} are characteristic of OH elongations, 3226 cm^{-1}, 3018 cm^{-1} and 2977 cm^{-1} correspond to hydration and elongation of OH, 1678 cm^{-1}, 1611 cm^{-1} is the band corresponding to the hydration and deformation of HOH, 1490 cm^{-1} traces of carbonates, 1051 cm^{-1} and 1003 cm^{-1} are characteristic of SiO elongations, 791 cm^{-1} and 682 cm^{-1} are SiO deformation bands, 667 cm^{-1} is the band corresponding to the deformation of OH. Whole-rock diffuse reflection infrared spectroscopy of materials (DTT3 and DTT4) Fig. 5 D, shows OH, HOH and SiO bonds. The band assignments are: 3676 cm^{-1}, 3614 cm^{-1}, the OH elongation probably of talc, 1673 cm^{-1}, 1603 cm^{-1}, hydration and HOH deformation, 1460 cm^{-1}, 1411 cm^{-1}, traces of carbonates, 1049 cm^{-1} and 1003 cm^{-1}, SiO elongations, 882 cm^{-1}, 853 cm^{-1}, 783 cm^{-1} and 728 cm^{-1}, SiO deformations, 681 cm^{-1} and 667 cm^{-1}, deformation of OH.

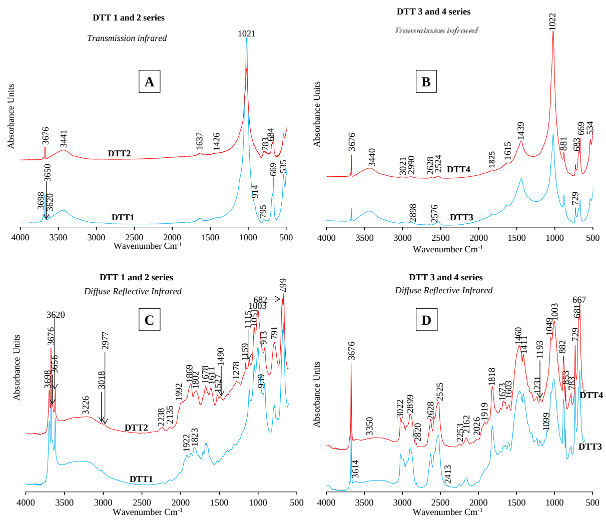

Figure 5: Infrared spectra in transmission (A and B) and diffuse reflection (C and D) of the Douigny on whole rock of the series (DTT1 - DTT2; DTT3 - DTT4)

The texture of mineral materials of the DTT3 and DTT4 series is lamellar and the quartz is fragmented. This quartz fragmentation justifies the texture of the cataclastic system showing tectonic activities with low regional metamorphism observed in Figs. 2 and 3. The morphology of talcschists in mineral materials of the DTT1 and DTT2 series presents micro-lamellar cracked to disordered fibrillar textures (Fig. 6).

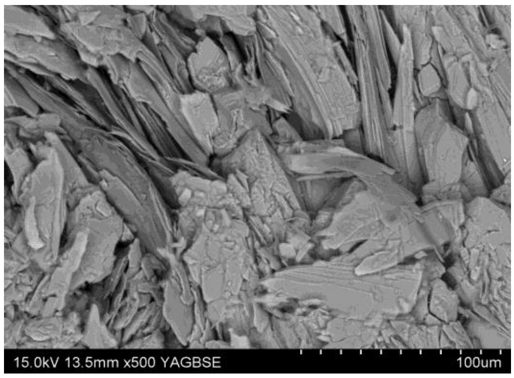

Figure 6: Scanning Electron Microscopy and EDS of La Douigny materials on whole rock

IV. Conclusion

Douigny talcschists can be used as fluxes (MgO oxide) in ceramics for the manufacture of glasses in order to lower the melting temperature and increase the resistance to chemical agents [16]. They can also be used as raw materials to manufacture refractories, in basic earth sintered magnesia systems with MgO (70-97), CaO (2-20), SiO2 (less than 20) or SiO2 (41-50) as mentioned it [17].

ACKNOWLEDGMENTS

The thanks of the authors go to the University of Lorraine for the fine analyzes, the Ecole Normale Supérieure of Libreville for its multifaceted support.

BIBLIOGRAPHIC REFERENCES

[1]. Thiéblemont D, Castaing C, Billa M, Bouton P, Préat A. (2009). Notice explicative de la Carte géologique et des Ressources minérales de la République Gabonaise à 1/1000 000. Editions DGMG - Ministère des Mines, du Pétrole, des Hydrocarbures, Libreville. 243 - 244 pp.
[2]. Boulingui J.-E. (2015). Inventaire des ressources en argiles du Gabon et leurs utilisations conventionnelles ou non dans les régions de Libreville et de Tchibanga. Thèse de Doctorat. Université de Lorraine - Université de Yaoundé1. 245p.
[3]. Poirier M, Boulingui J. E, Martin F, Mounguengui M. M, Nkoumbou C, Thomas F, Cathelineau M, Yvon J. (2019). Mineralogical and crystal-chemical characterization of the talc ore deposit of Minzanzala, Gabon. Clay Minerals, 54. 245–254 pp.
[4]. Lissoulour X, Barras X. (1948). Rapport de fin de mission- prospection de la région de la Nyanga et de la basse Nyanga Group VII juillet – octobre 1948. Document COGEME-CEA 48 GAB RSP-3.
[5]. Bellivier F. (1977). Prospection talc dans la région de Ndendé. Rapport BRGM 77 LIB 008.
[6]. Martini J., Makanga J.F. (2001). Carte métallogénique de la République Gabonaise au 1 :1 000 000 et notice explicative. Ministère des Mines, de l'Energie, du Pétrole et des Ressources hydrauliques du Gabon. Editions DGMG Gabon.
[7]. Boutin P. (1985). Talc du synclinal de la Nyanga (Gabon). Synthèses des travaux fin 1984. Rapport BRGM 85 LIB 003.
[8]. Legros J.P. (1996). Cartographie des sols : de l'analyse spatiale à la gestion des territoires. Presses polytechniques romandes, Lausanne, coll. ≪ Gérer l'environnement≫. 321p.
[9]. Frontier S. (1997). Stratégies d'échantillonnage en écologie. Ed. Masson. 470p.
[10]. Webster R., Olivier M.A. (2001). Géostatics for Environmental Scientists, Wiley & Sons, Chichester. 271p.
[11]. Farmer V.C. (1974). The infrared spectra of minerals. The Mineralogical Society ed. London. 539 p.
[12]. Njopwouo D. (1984). Minéralogie et physico-chimie des argiles de Bomkoul et de Balengou (Cameroun). Utilisation dans la polymérisation du styrène et dans le renforcement du caoutchouc naturel, Thèse Doct. Etat.Fac.Sci., Université de Yaoundé. 300 p.
[13]. Yvon J, Baudracco J, Cases J.M, Weiss J. (1990). Eléments de minéralogie quantitative en micro-analyse des argiles. In: Matériaux Argileux, Structures, Propriétés et Applications. SFMC – GFA. Paris. Decarreau A. éditeur, ISBN 2-903589-06-02, Partie IV, Chap. 3. 473 - 489 pp.
[14]. Pomerol C, Lagabrielle Y, Renard M, Guillot S. (2011). Eléments de Géologie Paris Dunod. 14^{è} édition. ISBN 978-2-10-055943-5. 54-56 pp.
[15]. Foucault A., Raoult J.F. (2005). Dictionnaire de Géologie, 6ème édition, Dunod, Paris. ISBN 2 10 049071 0. 24-25 pp.
[16]. Dequatremare M, Devers T. (2012). Précis des matériaux. De la conception aux contrôles. Dunod, Paris. ISBN 978-2-10-058221-1. 220 p.
[17]. Fantozzi G, Nièpce J.C, Bonnefont G. (2013). Les céramiques industrielles. Propriétés, mise en forme et applications. Dunod, Paris. ISBN 978-2-10-057739-2. 491 p.